

PATENT ABSTRACTS OF JAPAN

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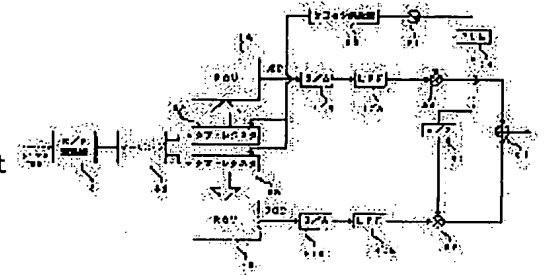
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(54) TRANSMITTER ADOPTING $\pi/4$ SHIFT QPSK

(57)Abstract:

PROBLEM TO BE SOLVED: To reduce the capacity of a memory of the transmitter that adopts the $\pi/4$ shift QPSK, calculates a waveform of data after passing through a Nyquist filter in advance and stores it in the memory.

SOLUTION: Assignment of data with respect to a symbol is conducted similarly to the case with a symbol of the 4-phase QPSK, and a mapping circuit 32 provides an output of position information of any of four symbols. The position information of transited symbols is latched in shift registers 6A, 6B and waveform data (I and Q components) in response to the information are read from ROMs 7A, 7B. The communication by the $\pi/4$ QPSK is conducted by increasing/decreasing the frequency of a carrier modulated by the I and Q components by $f_s/8$ (f_s is a symbol rate) with respect to a frequency f_c of the carrier at demodulation. Since number of symbols used by the transmitter is 4, no many addresses of the ROMs are required and the required memory capacity is reduced.



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CLAIMS

[Claim(s)]

[Claim 1] While being located in the equal distance from a coordinate core on a Gauss-Argand plane and defining four symbols whose mutual phase contrast of an adjacent symbol is $\pi/2$ Divide at a time 2 bits of binary-ized signal trains which are data which should be transmitted, and four kinds of data decided by these 2 bits are assigned to said four symbols, respectively. The signal-processing section which outputs the positional information of the symbol corresponding to the 2-bit data concerned as a digital signal, The shift register memorized while the array of the positional information of the symbol which the positional information of the symbol from this signal-processing section is incorporated one by one, and is observing to predetermined timing, and the symbol before and behind that shifts, While the in-phase component and orthogonal component of a data point by which it was beforehand calculated after letting the filter of a predetermined property in case a symbol changes pass match with transition of a symbol and are stored The digital signal corresponding to the array of the positional information of the symbol memorized by the shift register concerned outputted from said shift register is made into the address. If f_c and SHIMBORURE-TO are set to f_s , the frequency of the memory from which the in-phase component and orthogonal component of said data point are read, and the subcarrier for a recovery The subcarrier output section which a frequency is $f_c \cdot f_s / 8$ and outputs the 1st and 2nd subcarriers from which $\pi/2$ phase is shifted mutually, The 1st and the 2nd amplitude modulation section which carry out amplitude modulation of said 1st and 2nd subcarriers, respectively with the analog signal according to the in-phase component and orthogonal component which are read from said memory, The sending set of $\pi / 4$ shift QPSK characterized by having the synthetic section which compounds the modulation output from these [1st] and the 2nd amplitude modulation section, and outputs a synthetic wave.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] In the sending set of $\pi/4$ shift QPSK, this invention calculates beforehand the data point after letting a filter in case a symbol changes (for example, Nyquist characteristics) pass, stores it in memory, and relates to the technical field which transmits by reading the data point according to the array of transition of a symbol from memory.

[0002]

[Description of the Prior Art] There is QPSK (Quadrature Phase Shift Keying) as one of the modulation techniques in digital mobile communication. Although it is located in the equal distance from a coordinate core and this adjoins each other on a Gauss-Argand plane as shown in drawing 4, it can take four symbols (signal point) whose mutual phase contrast is $\pi/2$, and is assigning 2 bit data to each symbol. There is a method which considers as the technique which advanced QPSK further 1 step, and is called $\pi/4$ shift QPSK, and by this method, as shown in drawing 5, whenever it chooses one symbol corresponding to data, only $\pi/4$ is rotated for each symbol on a Gauss-Argand plane, and phase contrast between symbols is made into 45° and 135° degrees. In addition, O mark in drawing 5 and x mark show the symbol before and behind rotation, respectively, and show signs that it moves to the symbol to which the following data were assigned from the symbol to which (11) was assigned.

[0003] By the way, in this kind of communication mode, while removing interference between symbols, in order to add reservation of occupancy bandwidth, and a limit of contiguity (or degree contiguity) leakage power, it is required to use the filter of Nyquist characteristics. And when a low power is required like especially PDC (Personal Digital Cellular) and PHS (Personal Handy Phone System), or in order to treat high speed data like PHS, when DSP (Digital Signal Processor) is not of use for count The wave after letting a nyquist filter pass is calculated beforehand, without using DSP. The digital value of the result was memorized to ROM (Read Only Memory), and the method which outputs the output of the ROM through a D/A (Digital/Analog) converter one by one is adopted.

[0004] The response wave of data and a nyquist filter and sending-circuit configuration which were stored in ROM are explained below. Drawing 6 shows the response wave of a nyquist filter, and in order to give explanation intelligible, even if it compounds a wave only within two symbols, it shows signs (there is no intersymbol interference) that a symbol does not change. However, since it has the response characteristic of infinity length theoretically, in order to add a limit to the response time, a nyquist filter must hang a window function and must close count. Since the die length of a window has a bad influence on short π past π , contiguity leakage power, and a symbol point, count is closed as past of symbol observed, for example 5 symbol, and a total of 11 symbols of five subsequent symbols.

[0005] In the Gauss-Argand plane shown in drawing 7 here, the case where 2 bit data which should be transmitted move to E points from a symbol D point is considered. The data which should be stored in ROM are the migration locus of the data of E points from D point in drawing 7, and are eight data (interpolation data) corresponding to the wave of minute spacing specifically divided by π mark between D point and E points. Before this migration locus is not decided only

by D point and E points and passes along D point, it changes by whether the symbol of ***** was passed, and which symbol is passed after passing along E points. Although the example of drawing shows the case of migration of A point → D point → E point → H point, if the symbol in front of [of D point] one is except an A point, for example, a migration locus will also change. [0006] Therefore, D point → theoretically, although the response wave of the migration locus to E points, i.e., a nyquist filter, cannot be expressed that all the symbols of the past and the future are not taken into consideration, it adds a limit to the response time like previous statement in fact, and is giving it to ROM rather than E points by using the response wave corresponding to a total of 11 symbols in front of 5 symbols and after 5 symbols as data. The interpolation data between D point and E points correspond to the data point of the minute section divided by ** mark on a synthetic wave in drawing 6 .

[0007] If the relation between passage of the symbol of data which should transmit, and read-out of the data in ROM (wave-like locus data) is shown in drawing 8 , this example shows the situation of read-out of the wave-like locus data of ROM in the case of the data which should be transmitted moving with B→C→G→A→D→E→H→B→E→F→G, and moving to D→E located in the center of that transition. One in drawing 8 is a shift register, and a corresponding symbol (if it says correctly positional information of a symbol) is sent one by one with migration between symbols. The number of the symbols on a par with this shift register 1 is 11, and the address when reading the wave-like locus data at the time of migration to E points from the inside of ROM2 is equivalent to the combination of the symbol on a par with a shift register 1 from D point currently noted in migration of the above-mentioned symbol.

[0008] Although the transmissions itself are four values in $1 / 4\pi$ shift QPSK, since arrangement of a symbol is eight phases seemingly, the number of bits for pinpointing the location of a symbol is the triplet need, therefore the number of bits of the address is set to $x(\text{number on a par with shift register 1})(\text{number of bits which pinpoints location of symbol}) = 11 \times 3$. While the list of the symbol which the following symbol was incorporated and was memorized to predetermined timing until now moves to a shift register 1 The symbol in front of the oldest symbol, i.e., 4 symbols of E points, is extruded, and it disappears. In this way, it becomes the appearance by which the limit was added to the response time of a nyquist filter, and the wave-like locus data applied to migration to E points from D point currently noted in the time list of 11 symbols will be read from ROM in this example. The wave-like locus data in ROM which starts migration to E points from this D point are interpolation data of previous statement between D point on a response wave, and E points.

[0009] If the situation of storing of the data in ROM is shown in drawing 9 , according to the address which is the contents of the shift register, the data which specify the migration locus corresponding to migration of the symbol to observe, for example, eight interpolation data, are stored. That is, if an exaggerated sampling is performed 8 times in this case and the address is outputted from a shift register, while eight data corresponding to this address will be read one by one by the exaggerated sampling clock, and will be sent to a D/A converter like the after-mentioned and the positional information of the following symbol will go into a shift register after 8 clocks, the positional information of the symbol in front of 5 symbols of the symbol currently observed is extruded, and it disappears. The interpolation data in ROM are the in-phase component (I component) and orthogonal component (Q component) which specify a wave in fact.

[0010] When the whole sending-circuit configuration using such a ROM filter is shown in drawing 10 , 3 is a serial/parallel-conversion machine for dividing into 2 bits at a time the serial signal (binary-ized signal train after quantization) according to the data, for example, the sound signal, which should be transmitted, and outputting the 2-bit parallel signal. It assigns whether 3 is equivalent to which symbol of the symbols which are differential mapping circuits and said 2-bit parallel signal shows to drawing 5 . In $\pi / 4$ shift QPSK, since arrangement of a symbol is eight phases seemingly like previous statement, the positional information which pinpoints the location of a symbol is sent to the 1st and 2nd shift registers 1A and 1B from the differential mapping circuit 31 as symbol data of a triplet.

[0011] In shift registers 1A and 1B, as already explained, the positional information of a symbol is

incorporated one by one to predetermined timing, for example, the bit signal corresponding to a list and its list in 11 symbols is outputted to 1st and 2nd ROM2A and 2B as the address. From these ROM2A and 2B, I component and Q component of a data point corresponding to transition of the symbol to observe are outputted, I component is sent to 1st amplitude modulator 5A through 1st D/A-converter 41A and 1st low pass filter (LPF) 42A, and Q component is sent to 2nd amplitude modulator 5B through 2nd D/A-converter 41B and 2nd low pass filter 42B.

[0012] The subcarrier from an oscillator 51 which operates based on the clock outputted from the clock generation machine 50 on the other hand is inputted into 1st amplitude modulator 5A as it is, and amplitude modulation is carried out by I component from low pass filter 42A. Moreover, the phase shift of said subcarrier is carried out only $\pi/2$ with $\pi/2$ phase shifter 52, it is inputted into 2nd amplitude modulator 5B, and amplitude modulation is carried out by Q component from low pass filter 42B. The output of amplitude modulators 5A and 5B is compounded in the synthetic circuit 53, and is transmitted from the antenna which the synthetic wave does not illustrate.

[0013]

[Problem(s) to be Solved by the Invention] By the way, since the positional information of a symbol is a triplet when it is 11 symbols like previous statement of the die length of the window to the response wave of a nyquist filter, ROM according to the address which is $11 \times 3 = 33$ bit is needed, the storage capacity of ROM becomes huge, equipment is enlarged, and cost also has the problem of being high.

[0014] This invention aims at lessening memory space in the sending set which calculates the wave after letting a nyquist filter pass beforehand using $\pi/4$ shift QPSK, and stores the result in memory.

[0015]

[Means for Solving the Problem] While this invention defines four symbols whose mutual phase contrast of the symbol which is located in the equal distance and adjoins it is $\pi/2$ from a coordinate core on a Gauss-Argand plane in the sending set of $\pi/4$ shift QPSK Divide at a time 2 bits of binary-ized signal trains which are data which should be transmitted, and four kinds of data decided by these 2 bits are assigned to said four symbols, respectively. The signal-processing section which outputs the positional information of the symbol corresponding to the 2-bit data concerned as a digital signal, The shift register memorized while the array of the positional information of the symbol which the positional information of the symbol from this signal-processing section is incorporated one by one, and is observing to predetermined timing, and the symbol before and behind that shifts, While the in-phase component and orthogonal component of a data point by which it was beforehand calculated after letting the filter of a predetermined property in case a symbol changes pass match with transition of a symbol and are stored The digital signal corresponding to the array of the positional information of the symbol memorized by the shift register concerned outputted from said shift register is made into the address. If f_c and SHIMBORURE-TO are set to f_s , the frequency of the memory from which the in-phase component and orthogonal component of said data point are read, and the subcarrier for a recovery The subcarrier output section which a frequency is $f_c \cdot f_s / 8$ and outputs the 1st and 2nd subcarriers from which $\pi/2$ phase is shifted mutually, The 1st and the 2nd amplitude modulation section which carry out amplitude modulation of said 1st and 2nd subcarriers, respectively with the analog signal according to the in-phase component and orthogonal component which are read from said memory, It is characterized by having the synthetic section which compounds the modulation output from these [1st] and the 2nd amplitude modulation section, and outputs a synthetic wave.

[0016] The array of the positional information of the symbol which is memorized by the shift register here and which is observed and the symbol before and behind that is the semantics of the list of transition of the positional information of a symbol including the future symbol after passing the past symbol and past Symbol P which will have changed by the time it results in this symbol, when it is going to output the wave corresponding to a certain symbol P.

[0017]

[Embodiment of the Invention] Before explaining the configuration of the sending set of the gestalt

of operation of this invention, drawing 1 is used and explained about the outline of the gestalt of this operation. The phase of what eight symbols (signal point) shown by A1 – A4, and B1 – B4 in a Gauss–Argand plane adjoin has shifted by a unit of 45 degrees, and if it is conventional $\pi / 4$ shift QPSK, the group of A1 – A4 and the group of B1 – B4 will be set as the object of the data assignment (mapping) to alternation to the timing according to a symbol rate.

[0018] The gestalt of this operation realizes the communication mode of $\pi / 4$ shift QPSK, using only the positional information of four symbols which use the place which needed eight positional information with the 4 phase QPSK, since $\pi / 4$ shift QPSK needs eight symbols seemingly, by this, is going to reduce the number of the addresses of ROM and is going to suppress increase of memory space.

[0019] Although the symbol corresponding to data if it is conventional $\pi / 4$ shift QPSK when data change to (11) from (10) now, supposing the subcarrier is turning counterclockwise in drawing 1 changes to B–2 from A4, it is made to change to A1 seemingly from A4 in this example, i.e., data (11) are mapped as A1 and the positional information of A1 is outputted to a shift register. However, the way things stand, since it is the same as the conventional 4 phase QPSK, a subcarrier is brought forward only for $\pi / 4$ minutes. It is the semantics of bringing forward to the subcarrier when getting over bringing a subcarrier forward with a receiving set, and if the frequency of the subcarrier at the time of a recovery is set to f_c and a symbol rate is set to f_s , the carrier frequency used with a sending set will serve as a value $(f_c + f_s/8)$ which added $f_s/8$ to f_c .

[0020] Since transition to A1 from A4 requires only the time amount $(1/f_s)$ of transition for one symbol, it becomes the same as having changed to B–2 from A4 and the communication link having been performed by bringing f_c forward like **** according to this time amount. The data point corresponding to transition of this symbol stored in ROM is interpolation data between A1 and A4.

[0021] Although this example explains as that by which data move in the counterclockwise direction in the Gauss–Argand plane, it becomes the same as in the case of right–handed rotation, having assigned A1 to the degree of A4, having changed to B1 from A4 by delaying a subcarrier only for $\pi / 4$ minutes, and the communication link having been performed. That is, the frequency of the subcarrier used with a sending set in this case is set to $f_c - f_s/8$. Thus, this invention assigns a symbol like the 4 phase QPSK, and the description is in the point that only $f_s/8$ shifted carrier frequency to f_c .

[0022] Next, it explains, referring to drawing 2 about the circuitry for realizing such technique. The same sign is shown about the same part as drawing 10. The serial signal according to the data which should be transmitted is changed into a 2–bit parallel signal by the serial/parallel–conversion machine 3, and the positional information of a symbol is outputted from the mapping circuit 32 according to this parallel signal. Since mapping (assign a parallel signal to a symbol and output the positional information) performed here is the same as that of the 4 phase QPSK, differential mapping which was being performed in $\pi / 4$ shift QPSK is omitted.

[0023] Although the positional information of the assigned symbol is outputted from the mapping circuit 32, since the number of symbols is four, this positional information is a signal which is 2 bits, and the positional information of 11 symbols which contain every five symbols before and after the symbol (symbol to observe) which this 2–bit positional information is incorporated one by one by the 1st and 2nd shift registers 6A and 6B, for example, is going to transmit is memorized.

[0024] In 1st and 2nd ROM7A and 7B, the response data point of the nyquist filter corresponding to transition of 11 symbols which contain every five symbols approximately [the] is stored about the symbol which is going to transmit as the term of the conventional technique described. This data point is the same as the data in ROM2A which specifies the migration locus of data which connects the shift register which it is going to transmit, for example, and the symbol in front of one of them and which is eight interpolation data calculated beforehand, for example, and is shown in drawing 9, and 2B, the data of I component are stored in 1st ROM7A, and the data of Q component are stored in 2nd ROM7B, respectively. However, although the number of the address lines from shift register 1A (1B) in drawing 10 was 3×11 , in this example, since the positional

information of a symbol is specified by 2 bits, the number of the address lines from shift register 6A (6B) is 2×11 , and the number of bits of the address of the data in ROM7A (7B) is set to 2×11 . [0025] In shift registers 6A and 6B, while the positional information of the newest symbol is incorporated with the clock from the clock generation machine 50, the positional information of the oldest symbol is thrown away, and I component and Q component of a data point are read from ROMs 7A and 7B by making the array of the positional information of 11 symbols into the address, respectively. Said clock specifies the symbol rate f_s and the pulse separation of a clock are $1/f_s$ seconds. If the address is given to ROM7A (7B), eight interpolation data will be read one by one by the exaggerated sampling clock, and it will be inputted into amplitude modulator 5A (5B) through D/A-converter 41A (41B) and low pass filter 42A (42B).

[0026] As for the subcarrier outputted from an oscillator 51 on the other hand, only $f_s/4$ are brought forward by the phase locked loop (PLL) circuit 54. That is, it considers as the frequency of $f_c + f_s/4$. In addition, this f_c is the carrier frequency of transmission as stated above, and is also a frequency when getting over with a receiving set. In the 1st and 2nd amplitude modulators 5A and 5B, they are $\cos[2\pi(f_c + f_s/8)t]$ and $\sin[2\pi(f_c + f_s/8)t]$ (the subcarrier of $f_c + f_s/8$) is inputted, I component and Q component which are outputted from low pass filters 42A and 42B become irregular, respectively, and the modulation output is compounded in the synthetic section 53.). In this case, a symbol is left-handed rotation in drawing 1, and by the memory by the side of a receiving set, it has shifted the correspondence relation between the position coordinate of a symbol, and the data assigned to a symbol so that it may become left-handed rotation.

[0027] When transition of the symbol of drawing 7 mentioned as an example by the term of the conventional technique here is applied to this example, it comes to be shown in drawing 3. That is, when data change with (10) \rightarrow (01) \rightarrow (11) \rightarrow (00), as shown in a dotted line, with the conventional sending set, it is mapped with A4 \rightarrow B3 \rightarrow A2 \rightarrow B1, but in this example, the symbol assigned in the mapping circuit 32 serves as A4 \rightarrow A2 \rightarrow A2 \rightarrow A4, as the chain line shows. In a receiving side, the data of (10) \rightarrow (01) \rightarrow (11) \rightarrow (00) get over by using the receiving set of conventional $\pi/4$ shift QPSK as it is.

[0028] As mentioned above, according to the gestalt of this operation, the communication link by $\pi/4$ shift QPSK is realizable, since data are moreover transmitted as four symbols, the positional information of a symbol becomes 2 bits, and the address incorporated by 11 pieces, then ROMs 7A and 7B like **** in the number of the symbols memorized to a shift register becomes 11×2 bits. Therefore, since the one number of bits of the address becomes fewer compared with the case where data are transmitted, as eight symbols, the required memory space to ROMs 7A and 7B serves as half.

[0029]

[Effect of the Invention] According to this invention, memory space can be lessened in the sending set which calculates the wave after letting a nyquist filter pass beforehand using $\pi/4$ shift QPSK, and stores the result in memory.

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[0020] Since transition to A1 from A4 requires only the time amount $(1/f_s)$ of transition for one symbol, it becomes the same as having changed to B-2 from A4 and the communication link having been performed by bringing f_c forward like **** according to this time amount. The data point corresponding to transition of this symbol stored in ROM is interpolation data between A1 and A4.

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[0023] Although the positional information of the assigned symbol is outputted from the mapping circuit 32, since the number of symbols is four, this positional information is a signal which is 2 bits, and the positional information of 11 symbols which contain every five symbols before and after the symbol (symbol to observe) which this 2-bit positional information is incorporated one by one by the 1st and 2nd shift registers 6A and 6B, for example, is going to transmit is memorized.

[0024] In 1st and 2nd ROM7A and 7B, the response data point of the nyquist filter corresponding to transition of 11 symbols which contain every five symbols approximately [the] is stored about the symbol which is going to transmit as the term of the conventional technique described. This data point is the same as the data in ROM2A which specifies the migration locus of data which connects the shift register which it is going to transmit, for example, and the symbol in front of one of them and which is eight interpolation data calculated beforehand, for example, and is shown in drawing 9, and 2B, the data of I component are stored in 1st ROM7A, and the data of Q component are stored in 2nd ROM7B, respectively. However, although the number of the address lines from shift register 1A (1B) in drawing 10 was 3×11 , in this example, since the positional information of a symbol is specified by 2 bits, the number of the address lines from shift register 6A (6B) is 2×11 , and the number of bits of the address of the data in ROM7A (7B) is set to 2×11 .

[0025] In shift registers 6A and 6B, while the positional information of the newest symbol is incorporated with the clock from the clock generation machine 50, the positional information of the oldest symbol is thrown away, and I component and Q component of a data point are read from ROMs 7A and 7B by making the array of the positional information of 11 symbols into the address, respectively. Said clock specifies the symbol rate f_s and the pulse separation of a clock are $1/f_s$ seconds. If the address is given to ROM7A (7B), eight interpolation data will be read one by one by the exaggerated sampling clock, and it will be inputted into amplitude modulator 5A (5B) through D/A-converter 41A (41B) and low pass filter 42A (42B).

[0026] As for the subcarrier outputted from an oscillator 51 on the other hand, only $f_s/4$ are

brought forward by the phase locked loop (PLL) circuit 54. That is, it considers as the frequency of $f_c + f_s/4$. In addition, this f_c is the carrier frequency of transmission as stated above, and is also a frequency when getting over with a receiving set. In the 1st and 2nd amplitude modulators 5A and 5B, they are $\cos \{2\pi(f_c + f_s/8) t\}$ and $\sin[2\pi (the subcarrier of $f_c + f_s/8$)] is inputted, I component and Q component which are outputted from low pass filters 42A and 42B become irregular, respectively, and the modulation output is compounded in the synthetic section 53.). In this case, a symbol is left-handed rotation in drawing 1 , and by the memory by the side of a receiving set, it has shifted the correspondence relation between the position coordinate of a symbol, and the data assigned to a symbol so that it may become left-handed rotation.$

[0027] When transition of the symbol of drawing 7 mentioned as an example by the term of the conventional technique here is applied to this example, it comes to be shown in drawing 3 . That is, when data change with (10) \rightarrow (01) \rightarrow (11) \rightarrow (00), as shown in a dotted line, with the conventional sending set, it is mapped with A4 \rightarrow B3 \rightarrow A2 \rightarrow B1, but in this example, the symbol assigned in the mapping circuit 32 serves as A4 \rightarrow A2 \rightarrow A2 \rightarrow A4, as the chain line shows. In a receiving side, the data of (10) \rightarrow (01) \rightarrow (11) \rightarrow (00) get over by using the receiving set of conventional $\pi / 4$ shift QPSK as it is.

[0028] As mentioned above, according to the gestalt of this operation, the communication link by $\pi / 4$ shift QPSK is realizable, since data are moreover transmitted as four symbols, the positional information of a symbol becomes 2 bits, and the address incorporated by 11 pieces, then ROMs 7A and 7B like **** in the number of the symbols memorized to a shift register becomes 11x2 bits. Therefore, since the one number of bits of the address becomes fewer compared with the case where data are transmitted, as eight symbols, the required memory space to ROMs 7A and 7B serves as half.

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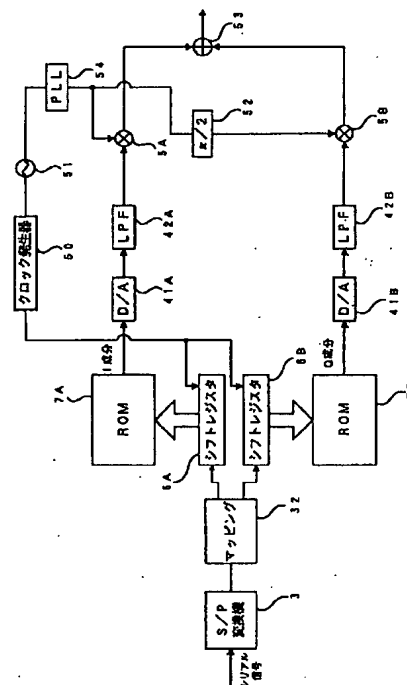
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(54) 【発明の名称】 $\pi/4$ シフトQPSKの送信装置

(57) 【要約】

【課題】 $\pi/4$ シフトQPSKを用い、ナイキストフ
ィルタを通した後の波形を予め計算してメモリに格納す
る送信装置において、メモリ容量を少なくする。

【解決手段】 シンボルに対するデータの割り当てを4
相QPSKのシンボルと同様に行い、マッピング回路3
2では4つのシンボルのいずれかのシンボルの位置情報
が出力される。シフトレジスタ6A、6Bには、推移す
るシンボルの位置情報が配列され、この配列に応じた波
形データ(I成分及びQ成分)がROM7A、7Bから
読み出される。これらI成分及びQ成分により変調され
る搬送波を、復調時の搬送波の周波数 f_c に対して f_s
 $/8$ (f_s はシンボルレート)だけ増減することによ
り、 $\pi/4$ QPSKの通信が行われ、しかも送信装置で
用いるシンボルは4個なので、ROMのアドレスが少な
くなり、必要なメモリ容量を低減できる。



【特許請求の範囲】

【請求項1】 複素平面上で座標中心から等距離に位置し、隣り合うシンボルの互いの位相差が $\pi/2$ である4個のシンボルを定めると共に、送信すべきデータである2値化信号列を2ビットずつ分け、この2ビットで決まる4通りのデータを前記4個のシンボルに夫々割り当てて、当該2ビットのデータに対応するシンボルの位置情報をデジタル信号として出力する信号処理部と、この信号処理部からのシンボルの位置情報が所定のタイミングで順次取り込まれ、注目しているシンボル及びその前後のシンボルの位置情報の配列がシフトしながら記憶されるシフトレジスタと、シンボルが推移するときの所定の特性のフィルタを通した後の予め計算された波形データの同相成分及び直交成分がシンボルの推移と対応づけて格納されると共に、前記シフトレジスタから出力される、当該シフトレジスタに記憶されたシンボルの位置情報の配列に対応するデジタル信号をアドレスとして、前記波形データの同相成分及び直交成分が読み出されるメモリと、復調用の搬送波の周波数を f_c 、シンボルレートを f_s とすると、周波数が $f_c \pm f_s/8$ であって、互いに $\pi/2$ 位相がずれている第1及び第2の搬送波を出力する搬送波出力部と、前記メモリから読み出される同相成分及び直交成分に応じたアナログ信号により前記第1及び第2の搬送波を夫々振幅変調する第1及び第2の振幅変調部と、これら第1及び第2の振幅変調部からの変調出力を合成して合成波を出力する合成部と、を備えたことを特徴とする $\pi/4$ シフトQPSKの送信装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、 $\pi/4$ シフトQPSKの送信装置において、シンボルが推移するときの例えばナイキスト特性のフィルタを通した後の波形データを予め計算してメモリに格納し、シンボルの推移の配列に応じた波形データをメモリから読み出して送信を行う技術分野に関するものである。

【0002】

【従来の技術】デジタル移動通信における変調技術の一つとしてQPSK (Quadrature Phase Shift Keying) がある。これは図4に示すように複素平面上で座標中心から等距離に位置し、隣り合うものの互いの位相差が $\pi/2$ である4つのシンボル (信号点) を取り得るもので、2ビットデータを各シンボルに割り当てている。QPSKを更に一步進めた技術として $\pi/4$ シフトQPSKと呼ばれる方式があり、この方式では、図5に示すようにデータに対応するシンボルを一つ選択する毎に複素平面上で各シンボルを $\pi/4$ だけを回転させ、シンボル間の位相差を $\pm 45^\circ$ 、 $\pm 135^\circ$ としている。なお図5中○印、×印は夫

々回転前後のシンボルを示しており、(11)が割り当てられたシンボルから、次のデータが割り当てられたシンボルに移動する様子を示している。

【0003】ところでこの種の通信方式においては、シンボル間干渉を取り除くと共に占有帯域幅の確保及び隣接 (または次隣接) 漏洩電力の制限を加えるためナイキスト特性のフィルタを使用することが必要である。そして特にPDC (Personal Digital Cellular) やPHS (Personal Handy Phone System) のように低消費電力が要求される場合、あるいはPHS等のように高速データを扱うためにDSP (Digital Signal Processor) では計算が間に合わない場合には、DSPを使用せずに、ナイキストフィルタを通した後の波形を予め計算し、その結果のデジタル値をROM (Read Only Memory) に記憶しておき、そのROMの出力を順次D/A (Digital/Analog) 変換器を介して出力する方式を採用している。

【0004】以下にROMに格納されたデータ、ナイキストフィルタのレスポンス波形及び送信回路構成に関して説明する。図6はナイキストフィルタのレスポンス波形を示し、説明を分かりやすくするために2つのシンボルに限って波形を合成しても、シンボルが変わらない

(符号間干渉がない) 様子を示す。しかしながらナイキストフィルタは理論的には無限長の応答特性を持つので応答時間に制限を加えるためにウィンドウ関数を掛けて計算を打ち切らなければならない。ウィンドウの長さが短か過ぎると隣接漏洩電力およびシンボル点に悪影響を与えるので、例えば注目するシンボルの過去5シンボル及びその後の5シンボルの合計11シンボルで計算が打ち切られる。

【0005】ここで図7に示す複素平面において、送信すべき2ビットデータがシンボルD点からE点に移動する場合について考える。ROMに格納すべきデータは、図7におけるD点からE点のデータの移動軌跡であり、具体的にはD点とE点との間の△印で区切られた微小間隔の波形に対応する8個のデータ (補間データ) である。この移動軌跡は、D点とE点とのみで決まるものではなく、D点を通る前に過去どのシンボルを通過したか、またE点を通った後、どのシンボルを通過するのかわによって変わる。図の例ではA点→D点→E点→H点の移動の場合を示しているが、例えばD点の一つ前のシンボルがA点以外であれば移動軌跡も変わってくる。

【0006】従ってD点→E点への移動軌跡、即ちナイキストフィルタのレスポンス波形は、理論的には過去、未来のシンボル全てを考慮しないと表わすことができないが、実際には既述のように応答時間に制限を加えてE点よりも5シンボル前及び5シンボル後の合計11シンボルに対応するレスポンス波形をデータとしてROMに

持たせている。D点とE点との間の補間データは、図6においては、合成波形上の△印で区切った微小区間の波形データに対応する。

【0007】送信すべきデータのシンボルの通過とROM内のデータ（波形の軌跡データ）の読み出しとの関係を図8に示すと、この例では送信すべきデータがB→C→G→A→D→E→H→B→E→F→Gと移動し、その推移の中央に位置するD→Eへ移動する場合のROMからの波形の軌跡データの読み出しの様子を示している。図8中1はシフトレジスタであり、シンボル間の移動に伴い、対応するシンボル（正確に言えばシンボルの位置情報）が順次送られてくる。このシフトレジスタ1に並ぶシンボルの数は例えば11個であり、上記のシンボルの移動において、注目しているD点からE点への移動時の波形の軌跡データをROM2内から読み出すときのアドレスが、シフトレジスタ1に並ぶシンボルの組み合わせに相当する。

【0008】 $1/4\pi$ シフトQPSKでは伝送そのものは4値であるが、シンボルの配置が見かけ上8相であるため、シンボルの位置を特定するためのビット数は、3ビット必要であり、従ってアドレスのビット数は（シフトレジスタ1に並ぶ数）×（シンボルの位置を特定するビット数）= 11×3 となる。シフトレジスタ1には所定のタイミングで次のシンボルが取り込まれて、今まで記憶されていたシンボルの並びが移動すると共に、最も古いシンボル即ちE点の4シンボル前のシンボルが押し出されて消え、こうしてナイキストフィルタの応答時間に制限が加えられた格好になり、この例では11個のシンボルの時間的並びの中で注目しているD点からE点への移動に係る波形の軌跡データがROMから読み出されることになる。このD点からE点への移動に係るROM内の波形の軌跡データとは、レスポンス波形上のD点とE点との間の既述の補間データである。

【0009】ROM内のデータの格納の様子を図9に示すと、シフトレジスタの内容であるアドレスに応じて、注目するシンボルの移動に対応する移動軌跡を特定するデータ、例えば8個の補間データが格納されている。つまりこの場合8倍オーバーサンプリングが行われ、シフトレジスタからアドレスが出力されると、このアドレスに対応する8個のデータがオーバーサンプリングクロックにより順次読み出されて後述の如くD/A変換器に送られ、8クロック後に次のシンボルの位置情報がシフトレジスタに入ると共に、注目しているシンボルの5シンボル前のシンボルの位置情報が押し出されて消える。実際にはROM内の補間データは、波形を特定する同相成分（I成分）及び直交成分（Q成分）である。

【0010】このようなROMフィルタを用いた送信回路の全体構成を図10に示すと、3は送信すべきデータ例えば音声信号に応じたシリアル信号（量子化後の2値化信号列）を2ビットづつに区切って、その2ビットの

パラレル信号を出力するためのシリアル/パラレル変換器である。3は差動マッピング回路であり、前記2ビットのパラレル信号が図5に示すシンボルのうちのどのシンボルに相当するかを割り当てるものである。 $\pi/4$ シフトQPSKでは既述のようにシンボルの配置が見かけ上8相であるため、シンボルの位置を特定する位置情報は3ビットのシンボルデータとして差動マッピング回路31から第1及び第2のシフトレジスタ1A、1Bに送られる。

【0011】シフトレジスタ1A、1Bでは、既に説明したように所定のタイミングでシンボルの位置情報が順次取り込まれて例えば11個のシンボルが並び、その並びに対応するビット信号がアドレスとして第1及び第2のROM2A、2Bに出力される。これらROM2A、2Bからは、注目するシンボルの遷移に対応する波形データのI成分及びQ成分が出力され、I成分は第1のD/A変換器41A及び第1のローパスフィルタ（LPF）42Aを介して第1の振幅変調器5Aに送られ、Q成分は第2のD/A変換器41B及び第2のローパスフィルタ42Bを介して第2の振幅変調器5Bに送られる。

【0012】一方クロック発生器50より出力されるクロックに基づいて動作する発振器51からの搬送波はそのまま第1の振幅変調器5Aに入力され、ローパスフィルタ42AからのI成分により振幅変調される。また前記搬送波は $\pi/2$ 移相器52で $\pi/2$ だけ移相されて第2の振幅変調器5Bに入力され、ローパスフィルタ42BからのQ成分により振幅変調される。振幅変調器5A、5Bの出力は合成回路53にて合成され、その合成波が図示しないアンテナから送波される。

【0013】

【発明が解決しようとする課題】ところでナイキストフィルタのレスポンス波形に対するウインドウの長さを既述のように例えば11シンボルとすると、シンボルの位置情報が3ビットであるため、 $11 \times 3 = 33$ ビットのアドレスに応じたROMが必要になり、ROMの記憶容量が膨大になり、装置が大型化し、コストも高いという問題がある。

【0014】本発明は、 $\pi/4$ シフトQPSKを用いて、ナイキストフィルタを通した後の波形を予め計算してその結果をメモリに格納する送信装置において、メモリ容量を少なくすることを目的とする。

【0015】

【課題を解決するための手段】本発明は、 $\pi/4$ シフトQPSKの送信装置において、複素平面上で座標中心から等距離に位置し、隣り合うシンボルの互いの位相差が $\pi/2$ である4個のシンボルを定めると共に、送信すべきデータである2値化信号列を2ビットづつ分け、この2ビットで決まる4通りのデータを前記4個のシンボルに夫々割り当てて、当該2ビットのデータに対応するシ

ンボルの位置情報をデジタル信号として出力する信号処理部と、この信号処理部からのシンボルの位置情報が所定のタイミングで順次取り込まれ、注目しているシンボル及びその前後のシンボルの位置情報の配列がシフトしながら記憶されるシフトレジスタと、シンボルが推移するときの所定の特性のフィルタを通した後の予め計算された波形データの同相成分及び直交成分がシンボルの推移と対応づけて格納されると共に、前記シフトレジスタから出力される、当該シフトレジスタに記憶されたシンボルの位置情報の配列に対応するデジタル信号をアドレスとして、前記波形データの同相成分及び直交成分が読み出されるメモリと、復調用の搬送波の周波数を f_c 、シンボルレートを f_s とすると、周波数が $f_c \pm f_s/8$ であって、互いに $\pi/2$ 位相がずれている第1及び第2の搬送波を出力する搬送波出力部と、前記メモリから読み出される同相成分及び直交成分に応じたアナログ信号により前記第1及び第2の搬送波を夫々振幅変調する第1及び第2の振幅変調部と、これら第1及び第2の振幅変調部からの変調出力を合成して合成波を出力する合成部と、を備えたことを特徴とするものである。

【0016】ここでシフトレジスタに記憶される、注目しているシンボル及びその前後のシンボルの位置情報の配列とは、あるシンボルPに対応する波形を出力しようとする場合、このシンボルに至るまでに推移してきた過去のシンボル及びシンボルPを通過した後の将来のシンボルを含めたシンボルの位置情報の推移の並びという意味である。

【0017】

【発明の実施の形態】本発明の実施の形態の送信装置の構成を説明する前に、この実施の形態の概要について図1を用いて説明する。複素平面においてA1～A4及びB1～B4で示す8個のシンボル（信号点）は、隣り合うもの同士の間隔が 45° ずつずれており、従来の $\pi/4$ シフトQPSKであれば、A1～A4のグループとB1～B4のグループとがシンボルレートに応じたタイミングで交互にデータ割り当て（マッピング）の対象になる。

【0018】この実施の形態は、 $\pi/4$ シフトQPSKが見かけ上8個のシンボルを必要とするので8個の位置情報を必要としていたところを、4相QPSKで用いる4個のシンボルの位置情報だけを用いながら $\pi/4$ シフトQPSKの通信方式を実現し、これによってROMのアドレスの数を減らし、メモリ容量の増大を抑えようとしている。

【0019】今データが（10）から（11）に変わる場合、従来の $\pi/4$ シフトQPSKであれば図1において搬送波が反時計方向に回っているとすると、データに対応するシンボルは、A4からB2に推移するが、本例ではA4からA1に見かけ上推移させる、つまりデータ（11）をA1としてマッピングし、A1の位置情報を

シフトレジスタに出力する。しかしこのままでは従来の4相QPSKと同じであるので、搬送波を $\pi/4$ 分だけ早めるようにする。搬送波を早めるとは、受信装置で復調するときの搬送波に対して早めるという意味であり、復調時の搬送波の周波数を f_c 、シンボルレートを f_s とすると、送信装置で用いる搬送波周波数は、 f_c に $f_s/8$ を加えた値（ $f_c + f_s/8$ ）となる。

【0020】A4からA1への推移は1シンボル分の推移の時間（ $1/f_s$ ）だけかかるので、この時間に合わせて上述の如く f_c を早めることにより、A4からB2に推移して通信が行われたことと同じになる。このシンボルの推移に対応する、ROM内に格納される波形データはA1、A4間の補間データである。

【0021】この例ではデータが複素平面を左回りに移動していくものとして説明しているが、右回りの場合には、A4の次にA1を割り当てて、搬送波を $\pi/4$ 分だけ遅らせることによりA4からB1に推移して通信が行われたことと同じになる。即ちこの場合には送信装置で用いる搬送波の周波数は $f_c - f_s/8$ となる。このように本発明は、4相QPSKと同様にシンボルを割り当て、搬送波周波数を f_c に対して $f_s/8$ だけずらした点に特徴がある。

【0022】次にこのような手法を実現するための回路構成について図2を参照しながら説明する。図10と同一部分については同一の符号を示してある。送信すべきデータに応じたシリアル信号はシリアル/パラレル変換器3により2ビットのパラレル信号に変換され、このパラレル信号に応じてマッピング回路32からシンボルの位置情報が出力される。ここで行われるマッピング（パラレル信号をシンボルに割り当ててその位置情報を出力すること）は4相QPSKと同様であるため、 $\pi/4$ シフトQPSKで行っていた差動マッピングは行っていない。

【0023】マッピング回路32からは、割り当てられたシンボルの位置情報が出力されるが、この位置情報はシンボルが4個であるため2ビットの信号であり、第1及び第2のシフトレジスタ6A、6Bにはこの2ビットの位置情報が順次に取り込まれ、例えば送信しようとするシンボル（注目するシンボル）の前後5個ずつのシンボルを含む11個のシンボルの位置情報が記憶される。

【0024】第1及び第2のROM7A、7B内には、従来技術の項で述べたように送信しようとするシンボルについて、その前後5個ずつのシンボルを含む11個のシンボルの推移に対応するナイキストフィルタのレスポンス波形データが格納されている。この波形データは、例えば送信しようとするシフトレジスタとその一つ前のシンボルとを結ぶデータの移動軌跡を特定する例えば8個の予め計算された補間データであって、図9に示すROM2A、2B内のデータと同じであり、第1のROM7A内にはI成分のデータが、また第2のROM7B内

にはQ成分のデータが夫々格納されている。ただし図10におけるシフトレジスタ1A(1B)からのアドレス線は 3×11 であったが、本例ではシンボルの位置情報が2ビットで特定されるのでシフトレジスタ6A

(6B)からのアドレス線は 2×11 であり、ROM7A(7B)内のデータのアドレスのビット数は 2×11 となる。

【0025】シフトレジスタ6A、6Bでは、クロック発生器50からのクロックにより最新のシンボルの位置情報が取り込まれると共に最も古いシンボルの位置情報が捨てられ、11個のシンボルの位置情報の配列をアドレスとしてROM7A、7Bから波形データのI成分及びQ成分が夫々読み出される。前記クロックはシンボルレート f_s を規定するものであり、クロックのパルス間隔は $1/f_s$ 秒である。ROM7A(7B)にアドレスが与えられるとオーバーサンプリングクロックにより例えば8個の補間データが順次読み出され、D/A変換器41A(41B)及びローパスフィルタ42A(42B)を通して振幅変調器5A(5B)に入力される。

【0026】一方発振器51から出力される搬送波はフェーズロックループ(PLL)回路54により $f_s/4$ だけ早められる。つまり $f_c + f_s/4$ の周波数とされる。なおこの f_c は既述の通り送信のキャリア周波数であり、受信装置で復調されるときに周波数でもある。第1及び第2の振幅変調器5A、5Bには $\cos\{2\pi(f_c + f_s/8)t\}$ 及び $\sin\{2\pi(f_c + f_s/8)t\}$ の搬送波が入力され、ローパスフィルタ42A、42Bから出力されるI成分及びQ成分によって夫々変調され、その変調出力が合成部53で合成される。この場合にはシンボルは図1において左回りであり、受信装置側のメモリでシンボルの位置座標とシンボルに割り当てられるデータとの対応関係を左回りとなるようにずらしている。

【0027】ここで従来技術の項で一例として挙げた図7のシンボルの推移を本例にあてはめてみると、図3に示すようになる。即ちデータが(10)→(01)→(11)→(00)と変化すると、従来の送信装置では点線に示すようにA4→B3→A2→B1とマッピングされるが、本例ではマッピング回路32で割り当てられるシンボルは鎖線で示すようにA4→A2→A2→A4となる。受信側では従来の $\pi/4$ シフトQPSKの受信装置をそのまま用いることにより、(10)→(01)→(11)→(00)のデータが復調される。

【0028】以上のように本実施の形態によれば、 $\pi/4$ シフトQPSKによる通信を実現することができ、し

かも4つのシンボルでデータを送信しているのでシンボルの位置情報が2ビットとなり、シフトレジスタに記憶するシンボルの数を上述の如く11個とすればROM7A、7Bに取り込まれるアドレスは 11×2 ビットとなる。従って8つのシンボルでデータを送信する場合に比べてアドレスのビット数が1つ減るので、ROM7A、7Bに対する必要なメモリ容量は半分となる。

【0029】

【発明の効果】本発明によれば、 $\pi/4$ シフトQPSKを用いて、ナイキストフィルタを通した後の波形を予め計算してその結果をメモリに格納する送信装置において、メモリ容量を少なくすることができる。

【図面の簡単な説明】

【図1】本発明の実施の形態の動作を複素平面上で概念的に説明する説明図である。

【図2】本発明の実施の形態の回路構成を示す構成図である。

【図3】本発明の実施の形態と従来の手法とにおいてマッピングの様子を比較して示す説明図である。

【図4】QPSKのシンボルを示す説明図である。

【図5】 $\pi/4$ シフトQPSKのシンボルを示す説明図である。

【図6】ナイキストフィルタを通した後のレスポンス波形を示す波形図である。

【図7】従来の $\pi/4$ シフトQPSKを用いて行うマッピングの一例を示す説明図である。

【図8】シフトレジスタからアドレスが出てROMからデータが読み出される様子を示す説明図である。

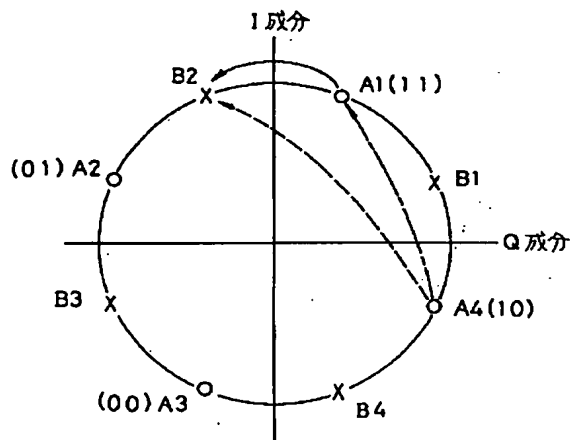
【図9】ROM内に格納されているデータを概念的に示す説明図である。

【図10】従来の $\pi/4$ シフトQPSKに用いられる送信装置の回路構成を示す構成図である。

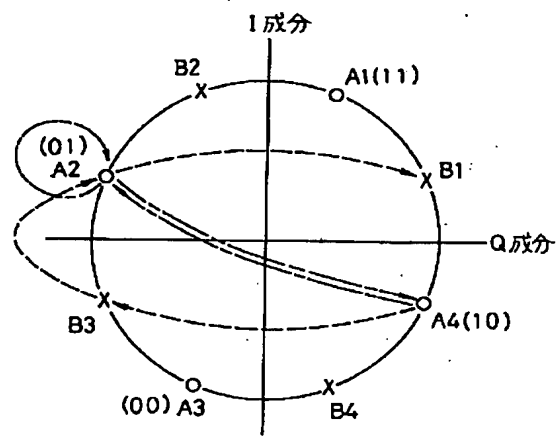
【符号の説明】

3	シリアル/パラレル変換器
32	マッピング回路
41A、41B	D/A変換器
42A、42B	ローパスフィルタ
5A、5B	振幅変調器
50	クロック発生器
51	発振器
52	移相器
53	合成回路
54	PLL回路
6A、6B	シフトレジスタ
7A、7B	ROM

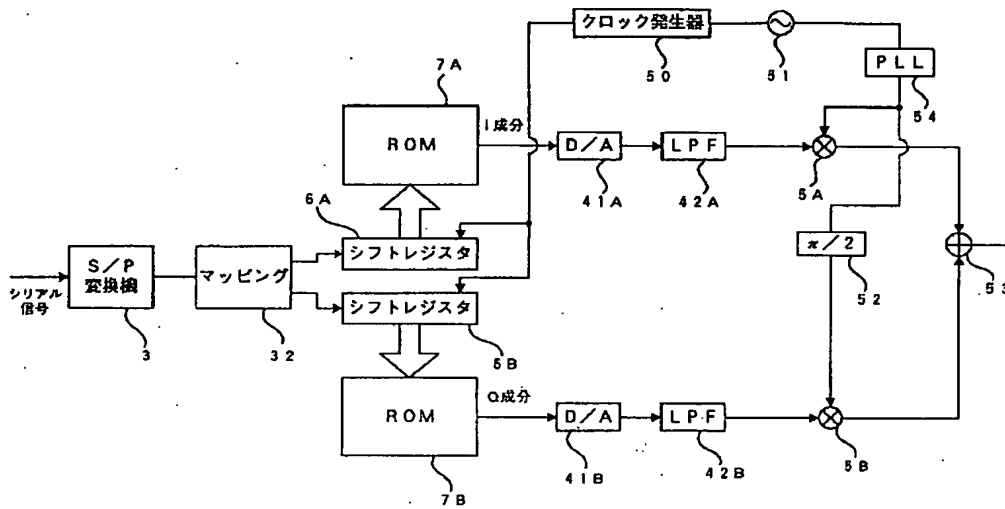
【図1】



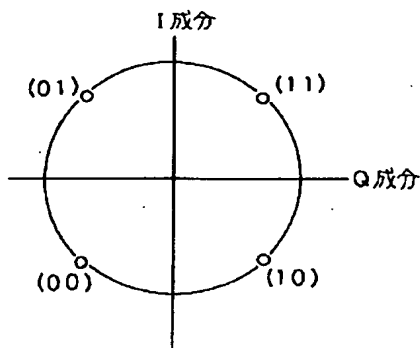
【図3】



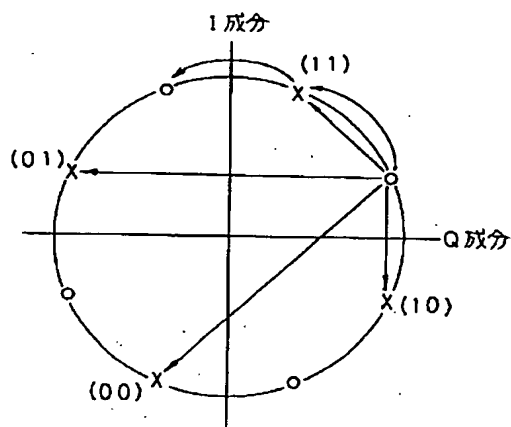
【図2】



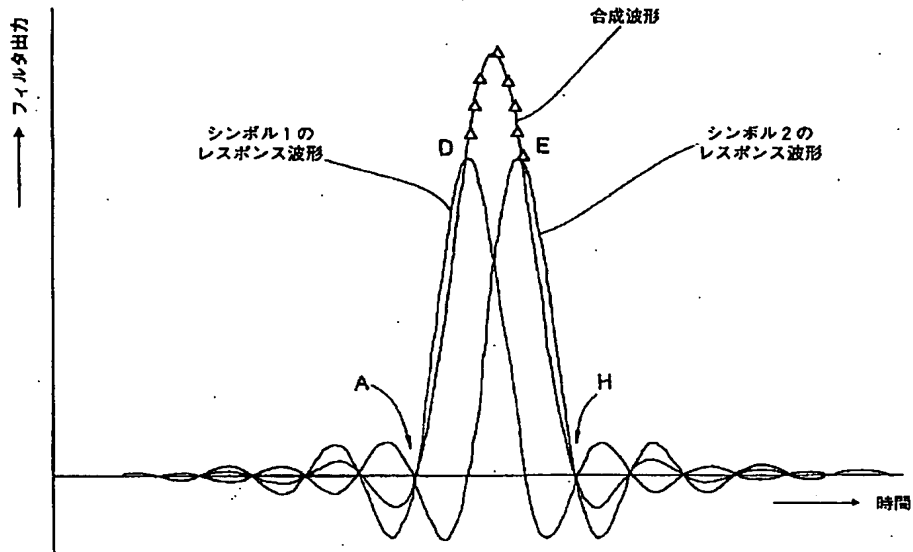
【図4】



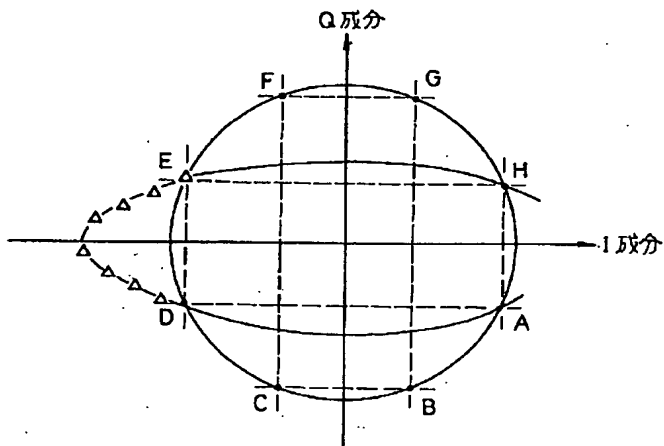
【図5】



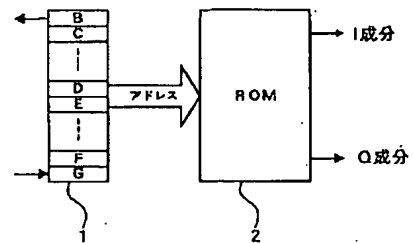
【図6】



【図7】



【図8】



【図9】

シンボルの配列(アドレス)	波形の軌跡データ
BCGADEHBEFG	1. I(Q)成分データ 2. I(Q)成分データ 3. I(Q)成分データ 4. I(Q)成分データ 5. I(Q)成分データ 6. I(Q)成分データ 7. I(Q)成分データ 8. I(Q)成分データ

【図10】

